General Aviation Accidents, 1983-1994: Identification of Factors Related to Controlled-Flight-Into-Terrain (CFIT) Accidents

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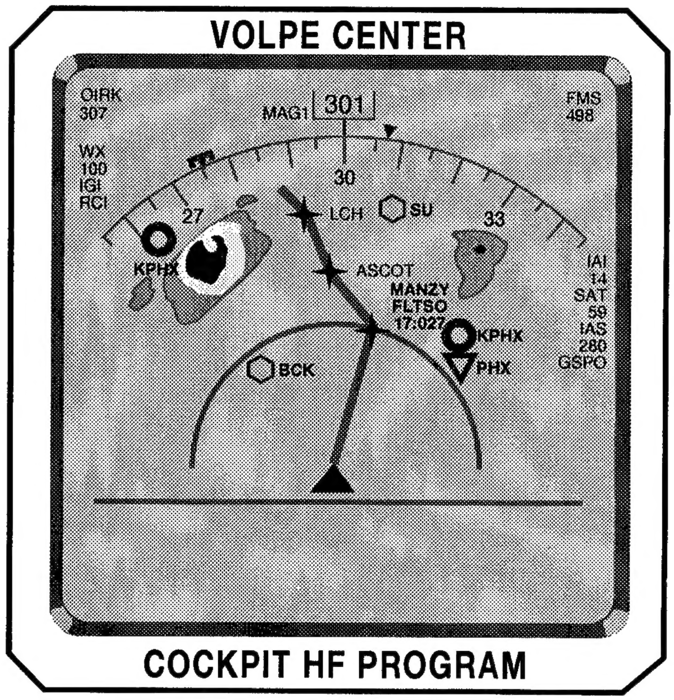

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Research and Special Programs Administration
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13. ABSTRACT (Maximum 200 words)

The purpose of this report is to describe the characteristics of general aviation (GA) accidents and to identify factors related to the occurrence of controlled-flight-into-terrain (CFIT) accidents in GA.

This study used the National Transportation Safety Board (NTSB) database of 31,790 aviation accidents that occurred between 1983 and 1994, inclusive. In the NTSB aviation accident database, 86.7% of these accidents were GA accidents. This study analyzed the subset of accidents involving GA airplanes and helicopters to investigate possible factors in CFIT accidents to guide further analyses and design of experiments to improve pilots' ability to avoid collisions with terrain.

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PREFACE

This report presents statistical analyses of aviation accidents conducted at the Volpe National Transportation Systems Center (Volpe Center) to investigate possible factors related to controlled-flight-into-terrain (CFIT) accidents. The conclusions drawn from this paper will be used for two purposes: one, to guide further analyses and two, to design experiments with electronic moving maps to study what and how information needs to be displayed to improve pilots' understanding of, and ability to, avoid terrain.

The authors would like to thank their FAA sponsors, Dr. Maureen Pettitt, Chief Scientific and Technical Advisor for Human Factors, and Dr. Thomas McCloy, manager of the Cockpit Human Factors Program, AAR-100, for their guidance and support of this work.

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
1 foot (ft) = 30 centimeters (cm)
1 yard (yd) = 0.9 meter (m)
1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)
1 acre = 0.4 hectare (ha) = 4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gm)
1 pound (lb) = .45 kilogram (kg)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
1 tablespoon (tbsp) = 15 milliliters (ml)
1 fluid ounce (fl oz) = 30 milliliters (ml)
1 cup (c) = 0.24 liter (l)
1 pint (pt) = 0.47 liter (l)
1 quart (qt) = 0.96 liter (l)
1 gallon (gal) = 3.8 liters (l)
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

°C=5/9(°F - 32)

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
1 centimeter (cm) = 0.4 inch (in)
1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm) = 0.036 ounce (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 liter (l) = 2.1 pints (pt)
1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallon (gal)
1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

°F=9/5(°C) + 32

QUICK INCH-CENTIMETER LENGTH CONVERSION

INCHES	0			1		2			3		4			5
CENTIMETERS	0	1	2	3	4	5	6	7	8	9	10	11	12	13

QUICK FAHRENHEIT-CELSIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. C13 10286.

Updated 8/1/96

EXECUTIVE SUMMARY

This report describes the characteristics of general aviation (GA) accidents and identifies factors related to the occurrence of controlled-flight-into-terrain (CFIT) accidents in GA.

This study used the National Transportation Safety Board (NTSB) database of 31,790 aviation accidents that occurred between 1983 and 1994, inclusive. In the NTSB aviation accident database, 86.7% of these accidents were GA accidents. This study analyzed the subset of accidents involving GA airplanes and helicopters.

A controlled-flight-into-terrain accident (CFIT) is any collision with terrain (or water) in which the pilot was in control of the aircraft but was not aware of the airplane's altitude, the terrain elevation, or the airplane's position in terms of latitude or longitude. This study classified all GA accidents as occurring due to either CFIT or other causes. Further analyses identified factors that were related significantly to GA accidents due to CFIT.

These analyses show that 4.7% of GA accidents occur due to CFIT; these accidents result in 1.4 fatalities per accident, compared with 0.33 fatalities in all other GA accidents. CFIT-type accidents account for 17% of GA fatalities. Instrument conditions and older pilots are factors associated with CFIT-type accidents. Approximately one-third (32%) of the GA accidents in instrument conditions are related to CFIT. Analyses of this database provided insight into factors related to CFIT-type GA accidents.

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1. BACKGROUND

A controlled-flight-into-terrain accident (CFIT) is defined as any collision with terrain (or water) in which the pilot was in control of the aircraft but was not aware of the airplane's altitude, the terrain elevation, or the airplane's position in terms of latitude or longitude, a definition similar to that described by Earl L. Wiener (1977).[1] Although Wiener's definition indicates that the pilot was in control of the aircraft and impacted terrain, it does not mention the airplane's position in terms of latitude and longitude. The custom data set created for this study includes accident data involving only airplanes or helicopters as our CFIT definition does not apply to other aircraft (e.g., ultralights, blimps).

The introduction of Ground Proximity Warning Systems (GPWS) into the U.S. air carrier fleet after the 1974 TWA crash at Washington Dulles International Airport has led to a reduction in CFIT-type accidents. GPWS has not completely eliminated CFIT-type accidents in air carriers. Because radar altimeter looks only downward, GPWS can provide only a few seconds' advance warning. GPWS can have false alarms which may affect pilot response.

As a result, manufacturers have developed improved Ground Collision Avoidance Systems (GCAS) and Enhanced Ground Proximity Warning Systems (EGPWS). These system upgrades to existing GPWS installations are expensive for general aviation (GA) operators whose aircraft may lack radar altimeters and integrated caution and warning systems; however, there is strong evidence that these GPWS systems are important for reorienting pilots who have lost situational awareness.[2] Phillips (1996) suggests that GA aircraft might also experience a reduced incidence of CFIT due to the benefits of GPWS or GCAS systems. To meet these concerns, commercial interest has begun to focus on developing lower cost, stand-alone, GPS-based GCAS systems for GA use.

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[1] Wiener, E. L. (1977). Controlled Flight into Terrain Accidents: System-Induced Errors. *Human Factors,* 19(2), 171-181. Wiener defines CFIT as, "...those [accidents] in which an aircraft, under the control of the crew, is flown into the terrain (or water) with no prior awareness on the part of the crew of the impending disaster."

[2] Khatwa, R., & Roelen, A. L. C. (1996). An Analysis of Controlled-flight-into-terrain (CFIT) Accidents of Commercial Operators 1988 through 1994. *Flight Safety Digest,* 15(4/5), 1-45.

2. PURPOSE

It is necessary to understand the factors associated with GA accidents to improve alerting equipment for GA operations. Since GCAS and GPWS systems alert for terrain avoidance, specific interest focuses on the factors associated with CFIT accidents in GA flight. By examining a database of aviation accidents it is possible to identify common patterns in CFIT accidents which will be useful in designing or modifying terrain alerting systems.

3. DESIGN AND PROCEDURE

This study uses the National Transportation Safety Board's (NTSB's) database of the 31,790 aviation accidents which occurred between 1983 and 1994, inclusive. GA accidents were identified using the "Regulation Flight Conducted Under" code on the NTSB Report Form. GA accidents are defined as "14 CFR 91 (*only*)" in this code. GA accidents were selected from the database for further study. The GA subset of the NTSB database of aviation accidents accounted for 86.7% of the NTSB database of all aviation accidents.[3]

The Volpe Center developed an operational definition for CFIT to identify factors associated with this classification. The customized data set was designed classifying each accident as a CFIT or non-CFIT-type accident. Classifying the data as CFIT or non-CFIT required several steps. First, the database was queried using keywords to designate the majority of the accidents as due to causes other than CFIT. Each of the remaining accidents were rated on an individual basis to determine which were due to CFIT and which were due to other causes. These steps are outlined in Appendix A. GA accidents classified as CFIT represented 1,260 accidents in the GA database of 26,533 accidents.

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[3] Note: In addition to the analysis of GA accidents, this study analyzed all the aviation accidents in the database, which includes both GA and non-GA accidents. The results of these analyses are presented in Appendix B. Because GA accidents account for 86.7% of all aviation accidents, the results of the statistical analyses on the encompassing database mirror the results reported for the GA accidents.

The remaining 13.3% of the accidents (non-GA) were also analyzed in a similar manner to the other two groups. These results are presented in Appendix C. Because this sector of the database is defined as being all accidents "other than" GA, there is variability in the profiles of pilots and aircraft, producing a slightly different picture than the other two analyses.

4. ANALYSIS

4.1 DISTRIBUTION OF GENERAL AVIATION ACCIDENTS BY YEAR

Figure 4-1 and table 4-1 show that, from 1983 to 1994, inclusive, the proportion of CFIT-type accidents has remained relatively constant, while the incidence of GA accidents due to all other causes has declined.

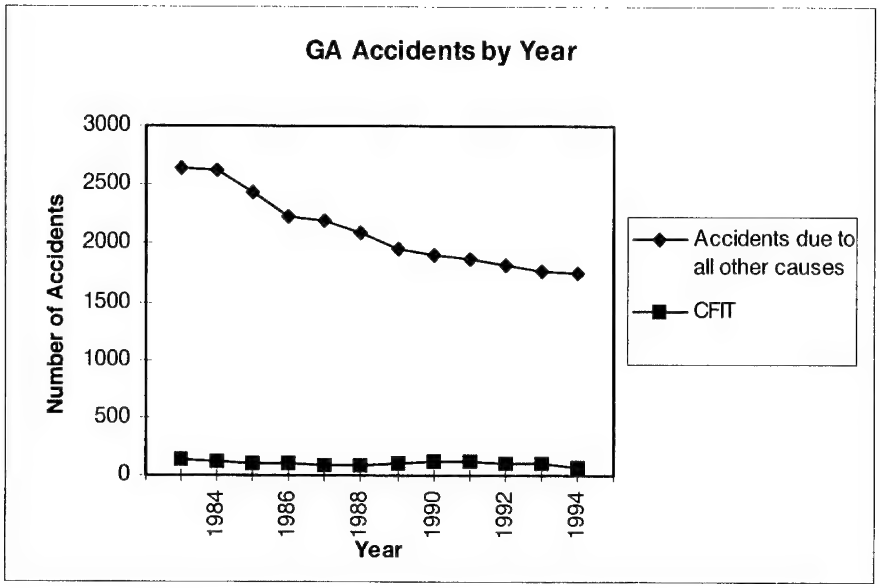

Figure 4-1. Trend in General Aviation Accidents, 1983-1994

Table 4-1. Frequency Distribution of General Aviation Accidents, 1983-1994

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total
Total number GA accidents	2,765	2,732	2,534	2,335	2,291	2,185	2,059	2,026	1,992	1,918	1,883	1,813	26,533
CFIT accidents	132	113	107	99	90	90	107	116	121	108	109	68	1,260
Accidents due to other causes	2,633	2,619	2,427	2,236	2,201	2,095	1,952	1,910	1,871	1,810	1,774	1,745	25,273
% CFIT accidents	4.77	4.14	4.22	4.24	3.93	4.12	5.20	5.73	6.07	5.63	5.79	3.75	4.75

4.2 TESTS OF SIGNIFICANCE

This study analyzed the relationship between visual conditions, pilot characteristics, aircraft characteristics, and the likelihood of a CFIT-type accident. Table 4-2 presents frequency distributions for all GA accidents, CFIT-type accidents, and for GA accidents due to all other causes.

Table 4-2. Incidence of General Aviation Accidents and Fatalities and CFIT Accidents and Fatalities by Visual Condition, Pilot, and Aircraft Characteristics, 1983-1994*

	GA Accidents	CFIT Accidents		Accidents due to other causes	
GA ACCIDENTS AND FATALITIES	N	N	%	N	%
GA Accidents:1983-1994	26,533	1,260	4.75	25,273	95.25
Mean number of GA Accidents per Year	*2,211*	*105*		*2,106*	
Fatal GA Accidents: 1983-1994	5,310	858	16.16	4,452	83.84
Mean number of Fatal GA Accidents per Year	*443*	*72*		*371*	
GA Fatalities: 1983-1994	10,241	1,789	17.47	8,452	82.53
Mean number of GA Fatalities per Accident	*0.39*	*1.42*		*0.33*	
VISUAL CONDITION					
GA Accidents in VMC conditions	24,053	515	2.14	23,538	97.86
Mean GA accidents per year (VMC)	*2,004*	*43*		*1,962*	
GA Accidents in IMC conditions	2,142	680	31.75	1,462	68.25
Mean GA accidents per year (IMC)	*179*	*57*		*122*	
Dawn	240	17	7.08	223	92.92
Daylight	20,239	486	2.4	19,753	97.6
Overcast	709	126	17.77	583	82.23
Dusk	979	61	6.23	918	93.77
Bright Night	425	34	8	391	92
Dark night	2,524	468	18.54	2,056	81.46
PILOT CHARACTERISTICS					
Pilots age 50 and over	8,026	433	5.39	7,593	94.61
Pilots under age 50	18,507	827	4.47	17,680	95.53
Male pilots	25,180	1,226	4.87	23,954	95.13
Female pilots	984	27	2.74	957	97.26
Pilots with more flying time**	4,454	244	5.48	4,210	94.52
Pilots with less flying time**	7,289	272	3.73	7,017	96.27
VFR rated pilots	14,628	566	3.87	14,062	96.13
VFR rated pilots in VMC	13,759	263	1.91	13,496	98.09
VFR rated pilots in IMC	869	303	34.87	566	65.13
IFR rated pilots	11,103	625	5.63	10,478	94.37
IFR rated pilots in VMC	9,850	249	2.53	9,601	97.47
IFR rated pilots in IMC	1,253	376	30.01	877	69.99
AIRCRAFT CHARACTERISTICS					
Single engine	23,559	1,040	4.41	22,519	95.59
Multi-engine	2,803	220	7.85	2,583	92.15

* Source: National Transportation Safety Board Database of Factual Aviation Report Forms.
Includes only airplane and helicopter accidents.

** More flying time means pilots' total flight hours ranked in the highest 25% of flight hours in the NTSB database. Less flying time means pilots' total flight hours were in the lowest 25% of flight hours in the NTSB database.

Tests of significance (chi-square) determined the relationship between visual condition, pilot or aircraft characteristics, and the type of accident. Table 4-3 reports statistically significant relationships. The significant relationships were further analyzed using logistic regressions to assess the relative contribution of variables measuring visual conditions, pilot, or aircraft characteristics to the likelihood of an accident occurring due to CFIT.

Table 4-3. Visual Condition, Pilot, and Aircraft Characteristics, and Incidence of CFIT-Type Accidents

Characteristics	Chi-Square probability	Notes
Weather conditions: VMC conditions versus IMC	$p = 0.000$	Accidents that happened in IMC were more likely to be CFIT than accidents in VMC.
Light conditions: Night: Bright night versus dark night	$p < 0.001$	Accidents that occurred on dark nights were more likely to be CFIT than accidents that occurred on clear nights.
Daylight versus night	$p < 0.001$	Accidents that occurred at night were more likely to be CFIT than accidents that occurred during the day.
Cloud conditions: Clear versus overcast	$p < 0.001$	Accidents that occurred in cloudy conditions were more likely to be CFIT than accidents that occurred in clear or thin overcast conditions.
Pilot age: Less than age 50 versus age 50 and over	$p = 0.001$	Accidents that occurred with pilots 50 or older were more likely to be CFIT accidents than accidents that occurred with pilots under 50.
Pilot gender: male versus female	$p = 0.002$	Accidents that occurred with male pilots were more likely to be CFIT accidents than accidents that occurred with female pilots.
Pilot flight time: Pilots with more flying time versus pilots with less flying time*	$p < 0.001$	Accident with pilots in the bottom 25% (fewer hours) were more likely to be CFIT accidents than accidents with pilots in the upper 25% .
Pilot rating: VFR rated versus IFR rated	$p < 0.001$	Accidents that occurred with IFR rated pilots were more likely to be CFIT accidents than accidents that occurred with VFR rated pilots.
Pilot rating in IMC accidents: VFR rated pilots in IMC versus IFR rated pilots in IMC	$p = 0.021$	Accidents that happened in IMC with VFR pilots were more likely to be CFIT accidents than accidents in IMC with IFR pilots.
Number of engines: Single engine versus multi-engine	$p < 0.001$	Accidents with multiple engine aircraft were more likely to be CFIT than accidents with single engine aircraft.

* More flying time means pilots' total flight hours ranked in the highest 25% of flight hours in the NTSB database. Less flying time means pilots' total flight hours were in the lowest 25% of flight hours in the NTSB database.

Accidents with older pilots and accidents with multi-engine aircraft were both more likely to be CFIT accidents than accidents with both younger pilots and accidents with single engine aircraft. This relationship may be the result of older pilots being more likely to fly multi-engine aircraft than younger pilots. The statistical relationship between the number of aircraft engines and pilots' age (table 4-4) is significant. These two variables may interact to create a situation where older GA pilots are more CFIT-oriented than younger pilots.

Table 4-4. Number of Aircraft Engines Versus Pilot Age

Characteristics	Chi-Square probability	Notes
Single/multi-engine versus less than/greater than 50 years old	$p < 0.001$	Accidents with multiple engine aircraft were more likely to be flown by pilots 50 years or over than were single engine aircraft.

Using logistic regression, variables significantly related to the incidence of CFIT accidents, e.g., pilot age, sex, total flying time, rating, and weather condition, were analyzed to assess relative contribution of each dichotomized variable to the likelihood of having a CFIT-type accident. Weather condition and pilot age were the strongest predictors of the occurrence of CFIT accidents.

Logistic regressions were also performed to unravel what factors contributed to the significantly higher percentage of CFIT accidents involving older pilots. Logistic regressions were performed for IFR and VFR pilots to see how the variables of age and visual conditions were related to CFIT. Weather conditions were significantly associated with both IFR and VFR pilots in GA accidents. Pilot age, however, was only significant for IFR-rated pilots in GA accidents. Pilot age is statistically associated with the occurrence of CFIT only when the pilot has an IFR rating.

5. RESULTS

The following conclusions are drawn from these statistical analyses:

ACCIDENTS:

- CFIT-type accidents account for 4.7% of GA accidents.
- CFIT-type accidents account for 32% of GA accidents in IMC conditions.

FATALITIES:

- GA CFIT-type accidents result in an average of 1.4 fatalities per accident while GA accidents, due to all other causes, result in an average of 0.33 fatalities per accident.
- CFIT accidents account for 17% of people killed in GA accidents.
- Sixteen percent of the fatal GA accidents were due to CFIT.

ASSOCIATED CHARACTERISTICS:

- IFR-rated GA pilots, age 50 and over, have significantly more CFIT-type accidents than IFR-rated GA pilots under age 50.
- There were significantly more CFIT-type accidents during IMC conditions than during VMC conditions.

6. CONCLUSIONS

CFIT-type accidents account for 17% of GA fatalities, which underscores the need for further research into factors contributing to CFIT accidents.

CFIT-type accidents represent 32% of the GA accidents in IMC conditions. When looking at accidents in IMC weather conditions, other studies have also indicated that CFIT-type accidents play a major role.[4] Moving maps with terrain displays may provide a way to better orient GA pilots in low-visibility situations: electronic moving map displays may alert pilots to avoid accidents before they occur.

Instrument conditions and older pilots are overrepresented in CFIT accidents. IMC conditions may demand sensory or cognitive tasks which vary with age. Other studies have indicated that older pilots with low annual hours (a category that is primarily GA pilots) have a higher accident rate overall.[5] It has also been shown that CFIT rates are higher in situations where pilots inadvertently fly from VMC to IMC conditions.[6] These issues, differential sensory and cognitive capabilities, lower annual flight hours, and inadvertent flying into altered conditions, seem to contribute disproportionately to the incidence of CFIT accidents. Further examination of these relationships is warranted.

Accidents in multi-engine planes are disproportionately represented in the classification of accidents related to CFIT, and this relationship needs more study. Older pilots may be more likely to fly multi-engine planes. Alternatively, multi-engine aircraft may fly longer distances, and over unfamiliar terrain more frequently.

In summary, analyses of this partitioned database provide a way to identify factors that are associated with CFIT-type accidents.

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[4] AOPA Air Safety Foundation. (1996). *1996 Nall Report: Accident Trends and Factors for 1995*. Frederick, MD.

[5] Safety Analysis Division. (1982). *The Influence of Total Flight Time, Recent Flight and Age on Class III Pilot Accident Rates* . Washington, D.C.: Federal Aviation Administration.

[6] Khatwa, R., & Roelen, A. L. C. (1996). An Analysis of Controlled-flight-into-terrain (CFIT) Accidents of Commercial Operators 1988 through 1994. *Flight Safety Digest,* 15(4/5), 1-45.

7. REFERENCES

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Safety Analysis Division. (1982). *The Influence of Total Flight Time, Recent Flight and Age on Class III Pilot Accident Rates*. Washington, D.C.: Federal Aviation Administration.

Wiener, E. L. (1977). Controlled Flight into Terrain Accidents: System-Induced Errors. *Human Factors*, 19(2), 171-181.

APPENDIX A - PROCEDURES FOR KEYWORD QUERIES

The NTSB database has four sections: 1) Narrative, 2) Causes, 3) Sequence of Events, and 4) Core. The Narrative is a free-form description of what occurred. The Causes and Sequence of Events are compiled from pre-coded lists of causes and events. The Core section contains the technical and objective information about the pilot, passengers, aircraft dimensions, and weather conditions from the NTSB accident report.

This study classified accidents due to the following causes as non-CFIT-type accidents:

1. Pilot loss of control due to mechanical problems or pilot error
2. Intentional dangerous flying (aerobatics, crop dusting)
3. Crashes in the runway environment
4. Extreme weather affecting flight
5. In-flight breakup
6. Engine failure
7. Pilot physical impairment
8. Suicide

To designate accidents as due to causes other than CFIT, the Sequence of Events section of the accident database was queried using keywords. Keywords from the master list of Sequence of Events eliminated accidents from the CFIT pool based on the chosen criteria. These words included:

1. Physical impairment
2. Midair collisions
3. Aerobatics
4. Buzzing
5. Suicide
6. Incapacitation
7. Standing
8. Taxi
9. Fuel exhaustion
10. Fuel starvation
11. Aircraft control not maintained
12. Loss of engine power (total)
13. Loss of control
14. Alcohol
15. Impairment
16. Drug
17. Aerial application

It was not possible to identify all the non-CFIT accidents using keywords. The remaining accidents were hand-rated by reading the Narrative, Causes, and Sequence of Events

sections for each accident and designating the accident as due to causes other than CFIT if it met one of these criteria:

1. Crashes in the runway environment
2. Extreme weather affecting performance
3. In-flight breakup
4. Intentional aerobatics
5. Intentional buzzing (i.e., flying close to the ground)
6. Total power loss
7. Pilot loss of control
8. Possible CFIT but evidence for other causes
9. None of the above (but pilot aware of location/terrain)

The remaining accidents were classified as occurring due to CFIT.

APPENDIX B - ANALYSIS OF ALL AVIATION ACCIDENTS, 1983-1994

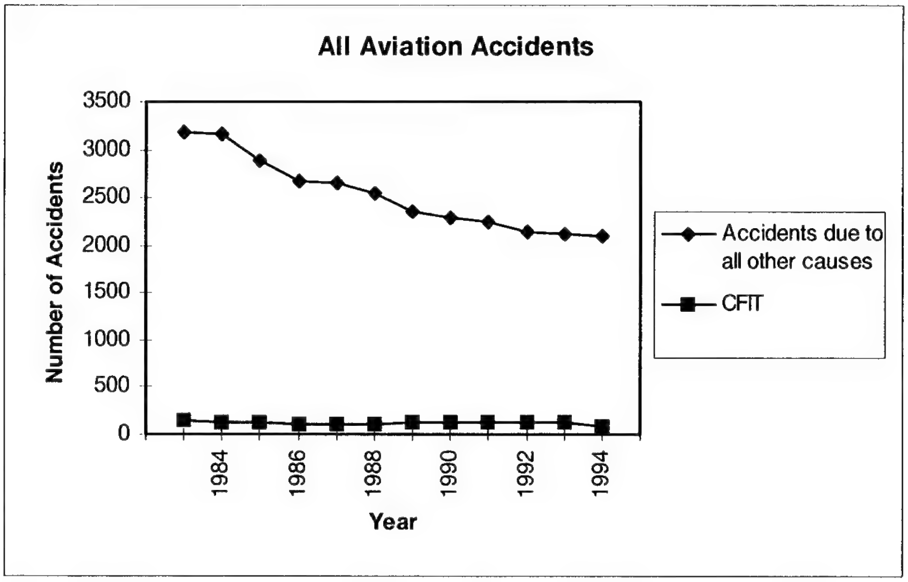

Figure B-1. Trend in All Aviation Accidents, 1983-1994

Table B-1. All Aviation Accidents by Year, 1983-1994

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total
Total number of accidents	3,333	3,287	3,005	2,776	2,774	2,636	2,482	2,435	2,389	2,278	2,246	2,181	29,340
CFIT accidents	144	122	121	113	102	99	127	136	135	130	126	78	1,433
Accidents due to other causes	3,189	3,165	2,884	2,663	2,642	2,537	2,355	2,299	2,251	2,148	2,120	2,103	27,907
% CFIT accidents	4.32	3.71	4.02	4.07	3.67	3.76	5.11	5.59	5.65	5.71	5.61	3.58	4.88

Table B-2. All Aviation Accidents and Fatalities, 1983-1994, Controlled-Flight-Into-Terrain (CFIT) Accidents, and Fatalities by Visual Condition, Pilot, and Aircraft Characteristics*

	Accidents	CFIT Accidents		Accidents due to other cause	
ALL AVIATION ACCIDENTS AND FATALITIES	N	N	%	N	%
Accidents:1983-1994	31,790	1,433	4.51	30,357	95.49
Mean number of Accidents per Year	*2,649*	*119*		*2,530*	
Fatal Accidents: 1983-1994	6,059	976	16.11	5,083	83.89
Mean number of Fatal Accidents per Year	*505*	*81*		*424*	
Fatalities: 1983-1994	14,303	2,161	15.11	12,142	84.89
Mean number of Fatalities per Accident	*0.45*	*1.51*		*0.4*	
VISUAL CONDITION					
Accidents in VMC conditions	28,670	569	1.98	28,101	98.02
Mean accidents per year (VMC)	*2,389*	*47*		*2,342*	
Accidents in IMC conditions	2,660	785	29.51	1,875	70.49
Mean accidents per year (IMC)	*222*	*65*		*156*	
Dawn	376	24	6.38	352	93.62
Daylight	26,018	759	2.92	25,259	97.08
Overcast	850	148	17.41	702	82.59
Dusk	1,130	63	5.58	1,067	94.42
Bright Night	530	38	7.17	492	92.83
Dark night	3,202	539	16.83	2,663	83.17
PILOT CHARACTERISTICS					
Pilots age 50 and over	9,110	470	5.16	8,640	94.84
Pilots under age 50	22,679	963	4.25	21,716	95.75
Male pilots	30,163	1,396	4.63	28,767	95.37
Female pilots	1,056	30	2.84	1,026	97.16
Pilots with more flying time**	7,689	346	4.5	7,343	95.5
Pilots with less flying time**	7,309	272	3.72	7,037	96.28
VFR rated pilots	5,530	232	4.2	5,298	95.8
VFR rated pilots in VMC	15,050	272	1.81	14,778	98.19
VFR rated pilots in IMC	889	306	34.42	583	65.58
IFR rated pilots	14,942	820	5.49	14,122	94.51
IFR rated pilots in VMC	13,013	294	2.26	12,719	97.74
IFR rated pilots in IMC	1,729	477	27.59	1,252	72.41
AIRCRAFT					
Single engine	26,785	1,132	4.23	25,653	95.77
Multi-engine	4,701	301	6.4	4,400	93.6

* Source: National Transportation Safety Board Database of Factual Aviation Report Forms. Includes only airplane and helicopter accidents.

** More flying time means pilots' total flight hours ranked in the highest 25% of flight hours in the NTSB database. Less flying time means pilots' total flight hours were in the lowest 25% of flight hours in the NTSB database.

Table B-3. Visual Conditions, Pilot, and Aircraft Characteristics, and Incidence of CFIT Accidents in the NTSB Aviation Accident Database

Characteristics	Chi-Square probability	Notes
Weather conditions: VMC conditions versus IMC	$p = 0.000$	Accidents that happened in IMC were more likely to be CFIT than accidents in VMC.
Light conditions: Night: Bright night versus dark night	$p < 0.001$	Accidents that occurred on dark nights were more likely to be CFIT than accidents that occurred on clear nights.
Daylight versus night	$p < 0.001$	Accidents that occurred at night were more likely to be CFIT than accidents that occurred during the day.
Cloud conditions: Clear versus overcast	$p < 0.001$	Accidents that occurred in cloudy conditions were more likely to be CFIT than accidents that occurred in clear or thin overcast conditions.
Pilot age: Less than age 50 versus age 50 and over	$p = 0.000$	Accidents that occurred with pilots 50 or older were more likely to be CFIT accidents than accidents that occurred with pilots under 50.
Pilot gender: male versus female	$p = 0.008$	Accidents that occurred with male pilots were more likely to be CFIT accidents than accidents that occurred with female pilots.
Pilot flight time: Pilots with more flying time versus pilots with less flying time*	$p = 0.018$	Accident with pilots in the bottom 25% (fewer hours) were more likely to be CFIT accidents than accidents with pilots in the upper 25% .
Pilot rating: VFR rated versus IFR rated	$p < 0.001$	Accidents that occurred with IFR rated pilots were more likely to be CFIT accidents than accidents that occurred with VFR rated pilots.
Pilot rating in IMC accidents: VFR rated pilots in IMC versus IFR rated pilots in IMC	$p < 0.001$	Accidents that happened in IMC with VFR pilots were more likely to be CFIT accidents than accidents in IMC with IFR pilots.
Number of engines: single engine versus multi-engine	$p < 0.001$	Accidents with multiple engine aircraft were more likely to be CFIT than accidents with single engine aircraft.

* More flying time means pilots' total flight hours ranked in the highest 25% of flight hours in the NTSB database. Less flying time means pilots' total flight hours were in the lowest 25% of flight hours in the NTSB database.

Accidents with older pilots and accidents with multi-engine aircraft were more likely to be due to CFIT than accidents with younger pilots and accidents with single engine aircraft. This relationship may be due to older pilots being more likely than younger pilots to fly multi-engine aircraft but the statistical relationship between the number of aircraft engines and pilots' age (table B-4) was not significant.

Table B-4. Number of Aircraft Engines Versus Pilot Age for All Aviation Accidents

Characteristics	Chi-Square probability	Notes
single/multi-engines versus less than/greater than 50 years old	p = 0.657	not significant

Using logistic regression, variables significantly related to the incidence of CFIT accidents, e.g., pilot age, sex, total hours, and rating, along with weather condition were analyzed. Weather condition (VMC vs. IMC) and pilot age (<50 and ≥50) most strongly predicted the incidence of CFIT accidents.

Logistic regressions for pilot age and weather examined the possibility that the significantly higher percentage of CFIT accidents with older pilots was due to the higher percentage of older pilots with IFR ratings, who were therefore, in IMC conditions more frequently. Two logistic regressions were performed, one with IFR pilots only, and one with VFR pilots only to see how age and weather condition contribute to CFIT.

The results of these regressions found that weather condition was significantly related to incidence of accidents for both IFR and VFR pilots. However, pilot age was only significantly related to accidents for IFR-rated pilots. Pilot age is associated with the occurrence of CFIT-type accidents when the pilot has an IFR rating. The relationship with age was not established for VFR-rated pilots.

APPENDIX C - ANALYSIS OF NON-GENERAL AVIATION ACCIDENTS, 1983-1994

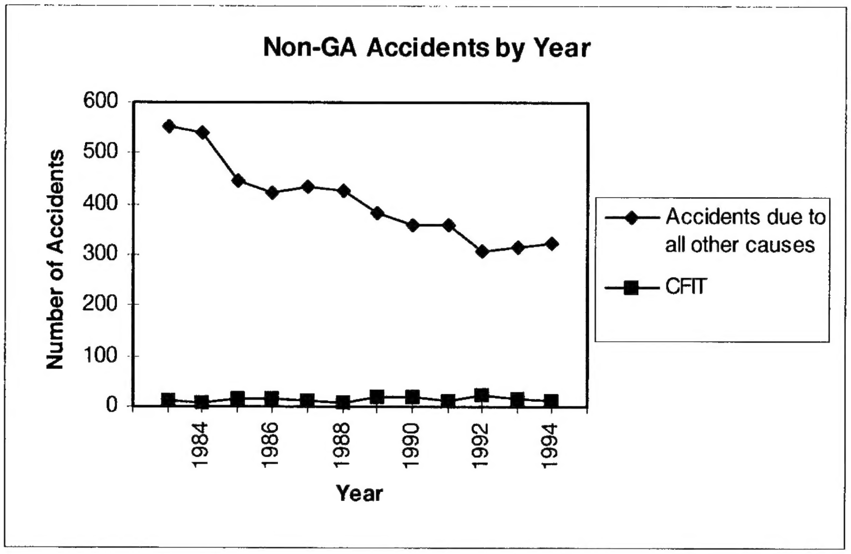

Figure C-1. Trend in Non-GA Accidents, 1983-1994

Table C-1. All Non-GA Accidents by Year, 1983-1994

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total
Total non-GA accidents	**563**	**548**	**460**	**438**	**446**	**435**	**404**	**380**	**370**	**330**	**334**	**334**	**5,042**
CFIT accidents	**12**	**9**	**14**	**14**	**12**	**9**	**20**	**19**	**12**	**22**	**17**	**10**	**170**
Accidents due to other causes	**551**	**539**	**446**	**424**	**434**	**426**	**384**	**361**	**358**	**308**	**317**	**324**	**4,872**
% CFIT accidents	**2.13**	**1.64**	**3.04**	**3.20**	**2.69**	**2.07**	**4.95**	**5.00**	**3.24**	**6.67**	**5.09**	**2.99**	**3.37**

Table C-2. Non-GA Accidents and Fatalities and Controlled-Flight-Into-Terrain (CFIT) Accidents and Fatalities by Visual Condition, Pilot, and Aircraft, 1983-1994*

	Non-GA Accidents	CFIT Accidents		Accidents due to other causes	
NON-GA ACCIDENTS AND FATALITIES	N	N	%	N	%
Non-GA Accidents:1983-1994	5,042	170	3.37	4,872	96.63
Mean number of Non-GA Accidents per Year	*420*	*14*		*406*	
Fatal Non-GA Accidents: 1983-1994	690	115	16.67	575	83.33
Mean number of Fatal Non-GA Accidents per Year	*58*	*10*		*48*	
Non-GA Fatalities: 1983-1994	3,709	369	9.95	3,340	90.05
Mean number of Non-GA Fatalities per Accident	*0.74*	*2.17*		*0.69*	
VISUAL CONDITION					
Non-GA Accidents in VMC conditions	4,468	51	1.14	4,417	98.86
Mean Non-GA accidents per year (VMC)	*372*	*4*		*368*	
Non-GA Accidents in IMC conditions	500	105	21	395	79
Mean Non-GA accidents per year (IMC)	*42*	*9*		*33*	
Dawn	136	7	5.15	129	94.85
Daylight	3,905	87	2.23	3,818	97.77
Overcast	133	22	16.54	111	83.46
Dusk	146	2	1.37	144	98.63
Bright Night	104	4	3.85	100	96.15
Dark night	663	70	10.56	593	89.44
PILOT CHARACTERISTICS					
Pilots age 50 and over	1,055	36	3.41	1,019	96.59
Pilots under age 50	3,987	134	3.36	3,853	96.64
Male pilots	4,874	167	3.43	4,707	96.57
Female pilots	69	3	4.35	66	95.65
Pilots with more flying time**	3,193	100	3.13	3,093	96.87
Pilots with less flying time**	12	0	0	12	100
VFR rated pilots	1,294	11	0.85	1,283	99.15
VFR rated pilots in VMC	1,270	8	0.63	1,262	99.37
VFR rated pilots in IMC	18	3	16.67	15	83.33
IFR rated pilots	3,623	158	4.36	3,465	95.64
IFR rated pilots in VMC	3,099	43	1.39	3,056	98.61
IFR rated pilots in IMC	472	101	21.4	371	78.6
AIRCRAFT CHARACTERISTICS					
Single engine	3,140	89	2.83	3,051	97.17
Multi-engine	1,853	81	4.37	1,772	95.63

* Source: National Transportation Safety Board Database of Factual Aviation Report Forms.
Includes only airplane and helicopter accidents.

** More flying time means pilots' total flight hours ranked in the highest 25% if flight hours in the NTSB database.
Less flying time means pilots' total flight hours were in the lowest 25% of flight hours in the NTSB database.

Table C-3. Visual Conditions, Pilot Characteristics, and Aircraft Characteristics and Incidence of CFIT Accidents for Non-GA Accidents

Characteristics	Chi-Square probability	Notes
Weather conditions: VMC conditions versus IMC	$p < 0.001$	Accidents that happened in IMC were more likely to be CFIT than accidents in VMC.
Light conditions: Night: Bright night versus dark night	$p = 0.048$	Accidents that occurred on dark nights were more likely to be CFIT than accidents that occurred on clear nights.
Daylight versus night	$p < 0.001$	Accidents that occurred at night were more likely to be CFIT than accidents that occurred during the day.
Cloud conditions: Clear versus overcast	$p < 0.001$	Accidents that occurred in cloudy conditions were more likely to be CFIT than accidents that occurred in clear or thin overcast conditions.
Pilot rating: VFR rated versus IFR rated	$p < 0.001$	Accidents that occurred with IFR rated pilots were more likely to be CFIT accidents than accidents that occurred with VFR rated pilots.
Pilot rating in VMC accidents: VFR rated pilots in VMC versus IFR rated pilots in VMC	$p = 0.050$	Accidents that happened in VMC with IFR pilots were more likely to be CFIT accidents than accidents in VMC with VFR pilots.
Second pilot present?: yes versus no	$p = 0.012$	Accidents without a second pilot present in the aircraft were more likely to be CFIT than accidents with a second pilot present.
Pilot relationship to aircraft: owner versus non-owner	$p < 0.001$	Accidents with aircraft not owned by the pilot were more likely to be CFIT than accidents with aircraft owned by the pilot.
Number of engines: single engine versus multi-engine	$p = 0.004$	Accidents with multiple engine aircraft were more likely to be CFIT than accidents with single engine aircraft.

* More flying time means pilots' total flight hours ranked in the highest 25% of flight hours in the NTSB database. Less flying time means pilots' total flight hours were in the lowest 25% of flight hours in the NTSB database.

The statistical relationship between the number of aircraft engines and pilots' age (<50 or ≥50).

Table C-4. Number of Aircraft Engines Versus Pilot Age for Non-GA Accidents

Characteristics	Chi-Square probability	Notes
single/multi-engines versus less than/greater than 50 years old	$p < .01$	Accidents with single engine aircraft were more likely to be flown by pilots over 50 years than accidents with multiple engine aircraft.